Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

MINERALOGICAL EXAMINATION OF COPPER AND NICKEL ORE SAMPLES FROM DEPOSITS NEAR MINGORA IN THE NORTH WEST FRONTIER PROVINCE, PAKISTAN

D. OWENS

MINERALOGY SECTION
PHYSICAL SCIENCES LABORATORY

MAY 1978

This document is an unedited interim report prepared primarily for discussion and internal reporting purposes. It does not represent a final expression of the opinion of the Canada Centre for Mineral and Energy Technology (CANMET)

Ce document est un rapport provisoire non-révisé et rédigé principalement pour fins de discussion et de documentation interne. Il ne représente nullement une expression définitive de l'opinion du Centre canadien de la technologie des minéraux et de l'énergie (CANMET)

Project MRP - 4.3.3.9.01
Federal Departments and Agencies

Job No. 024166

JAN 20 1984
MICROMEDIA
DECLASSIFIED
DATE 3/5/83
AUTHORIZED BY

12 pp

MINERALS RESEARCH PROGRAM

MINERAL SCIENCES LABORATORIES
REPORT MRP/MSL 78-11 (CF)

CONFIDENTIAL

Copy No. _____

MINERALOGICAL EXAMINATION OF COPPER AND NICKEL ORE SAMPLES FROM DEPOSITS NEAR MINGORA IN THE NORTH WEST FRONTIER PROVINCE, PAKISTAN

by

D. Owens*

INTRODUCTION

Ten ore samples reported to be from an area 18 miles East of Mingora in the North West Frontier Province of Pakistan were received from Mr. V.A. Haw, Deputy Director General, CANMET, on March 29, 1978. Mr. Haw requested that the samples be examined mineralogically in order to identify the ore minerals and to ascertain if they contain metals of economic value.

SAMPLES

Information accompanying the samples stated that they were equally divided between nickel- and copper-type ores. Each sample consisted of one to two small hand specimens measuring 1 to 2 inches in diameter. The information regarding the number, location and type of ore samples received is summarized in Table 1.

---

*Technician, Mineralogy Section, Physical Sciences Laboratory, CANMET, Department of Energy, Mines and Resources, 555 Booth Street, Ottawa, Ontario, Canada.

TABLE 1

Sample Number, Location and Type of Ore Sample

Sample No.	Location	Ore Type
NL-77-RSST-231	Nashnamal	copper
NL-77-RSST-234	Nashnamal	copper
SK-77-T-247	Shokani	copper
SK-77-R-249	Shokani	copper
SG-77-SSR-310	Shringal	copper
RK-77-S-20*	Cuzkotkai	nickel
NG-77-S-26	Naga	nickel
BK-77-SR-160	Bar Kotkai	nickel
KA-77-SR-175	Kishora	nickel
SH-77-S-302	Shangla	nickel

* Some confusion exists as to the correct number on this sample, because the letter(s) following the S were written over. It may be either SIC-20, SD-20. To simplify matters, it is listed as S-20.

METHOD OF INVESTIGATION

The megascopic characteristics of the samples were first determined by examination of the hand specimens under the binocular microscope. A representative polished section was then prepared of each sample and examined under the ore microscope to identify the minerals, their grain size and occurrence. Powder X-ray diffraction and electron microprobe analyses were used to confirm the identity of some of the minerals as well as to determine the nickel contents of the sulphides, iron oxides and silicates and silver values in some of the copper sulphides.

Except for one small fragment, the balance of each sample was crushed to minus 200 mesh and submitted for chemical analysis of specified elements. The selection of elements for

analyses was based on the results of the microscopic and electron microprobe studies and are given in Table 2.

TABLE 2

Sample Number and Analyses Requested

Sample No.	Elements
NL-77-RSST-231	Ag Au*
NL-77-RSST-234	Ag Au*
SK-77-T-247	Cu Ag
SK-77-R-249	Cu Ag
SG-77-SSR-310	Cu Ag
RK-77-S-20	Ni
NG-77-S-26	Ni
BK-77-SR-160	Ni
KA-77-SR-175	Ni Cu**
SH-77-S-302	Ni

*Cu not requested in either sample as both are essentially bornite.

**Cu requested because of presence of trace amounts of chalcopyrite.

RESULTS OF INVESTIGATION

Although a few of the samples exhibit some common mineralogical characteristics, each is sufficiently different to warrant a separate description of its mineralogy.

COPPER ORE SAMPLES

No. NL-77-RSST-231

This sample consists almost entirely of massive bornite with a small adjoining mass of quartz. The massive bornite is riddled with inclusions of digenite ($Cu_{1.8}S$) that has been partly replaced by metal-rich covelline ($Cu_{1+X}S$ = blaubleiblender) and

smaller amounts of "normal" covelline (CuS). The bornite also contains minor galena and exsolved minute lamallae of chalcopyrite. The bornite, digenite and metal-rich covelline are all penetrated by thin veinlets of malachite. These veinlets contain small amounts of iron hydroxide as minute blebs near the perimeter of the veinlets.

Electron microprobe analyses of the digenite, metal-rich and "normal" covellines confirmed their identities and showed that they contain trace amounts of silver (0.8-1.7 wt %). Silver was not detected in the bornite.

No. NL-77-RSST-234

Bornite, malachite, covelline, chalcocite, azurite and chalcopyrite are the copper-bearing minerals in this sample. Bornite is the major sulphide, with others occurring in minor to trace amounts. The bornite occurs as a large mass in a matrix of quartz. It is segmented by multiphase veinlets of malachite, goethite and either covelline or chalcocite. Azurite occurs as part of the malachite coating on the bornite. The bornite also contains a few minute inclusions of galena and exsolved lamellae of chalcopyrite. One grain of electrum (Au,Ag), measuring 2 microns in diameter, was observed in the bornite. Massive quartz is the major gangue mineral and is cut by a few extremely thin veinlets of malachite.

Electron microprobe analyses showed that the chalcocite contains 0.22 wt % silver. Copper and silica were detected in the goethite but are believed due to minute inclusions of quartz

and covelline. The other covelline grains were too small for analysis.

No. SK-77-247

The mineralization in this sample consists of several narrow bands of iron hydroxides, both crystalline and amorphous, cutting a siliceous matrix of quartz, chlorite and tourmaline. Smaller amounts of chalcopyrite, pyrite, malachite and trace amounts of covelline are associated with the iron hydroxides. X-ray powder diffraction analyses showed the crystalline iron hydroxide to be a mixture of lepidocrocite and goethite.

Chalcopyrite, the principal copper-bearing mineral present, occurs both as inclusions and fracture-fillings in the lepidocrocite-goethite and as remnants in the amphorous iron hydroxide. Malachite occurs essentially as thin veinlets in the gangue and covelline as thin discontinuous rims around the chalcopyrite remnants and as minute inclusions in gangue. Pyrite which is less prevalent than the chalcopyrite, also occurs as fracture-fillings and inclusions in the lepidocrocite-goethite and in some instances has been partly oxidized. A few disseminated grains of TiO_2 (anatase or rutile) occur in the siliceous matrix.

Neither the microscopical nor the electron microprobe studies of this sample could detect the presence of a silver-bearing phase. However, the microprobe analyses of the iron-hydroxides showed that trace amounts of both Cu and Si occur in the lepidocrocite-goethite. More significant amounts are present in the amorphous

phase, as are trace amounts of S. The lepidocrocite contains 2.6 wt % Cu and 1.1 wt % Si whereas the amorphous material averages 14.0 wt % Cu, 5.1 wt % Si and 0.3 wt % S. It could not be determined what portion of these values may be due to unresolved inclusions of copper sulphides or quartz, particularly in the amorphous iron hydroxide.

No. SK-77-R-249

This sample is almost barren of economic minerals. The only minerals present include minute amounts of pyrite, goethite, rutile or anatase and chalcopyrite, disseminated in a siliceous gangue composed of quartz, tourmaline and chlorite. The chalcopyrite occurs as minute blebs in quartz, the pyrite as slightly coarser grains partly replaced by goethite and the anatase or rutile as minute scattered stringers. No silver-bearing minerals were identified.

No. SG-77-SSR-310

This sample is the most highly altered of all of the copper ore type samples. Chalcopyrite is the most common mineral followed by somewhat lesser amounts of malachite and small to trace amounts of digenite, chalcocite and covelline. Other minerals present include pyrite, lepidocrocite-goethite, amorphous iron-hydroxide and rutile or anatase. The gangue matrix consists essentially of quartz with minor chlorite and trace amounts of tourmaline.

All the chalcopyrite has been partly altered. It is rimmed by thin layers of digenite and covelline and enclosed in an iron oxide (amorphous?). Thin veinlets of malachite penetrate between some of these chalcopyrite grains. The remaining malachite occurs as thin veinlets or inclusions in the quartz. In addition, a few grains of chalcocite with chalcopyrite cores and small grains of covelline are disseminated in the gangue.

Lesser amounts of pyrite are associated with the chalcopyrite as inclusions or adhering grains of which some have been partly replaced.

Both lepidocrocite and goethite were identified and occur as inclusions in the amorphous iron oxide. The elements detected in these minerals are in the same order of abundance as discussed in Sample No. SG-77-247. Silver is absent.

NICKEL ORE SAMPLES

No. RK-77-S-20

This sample consists of forsterite and antigorite with numerous small disseminated grains of magnetite and fewer but larger grains of chromite. Several grains of nickel sulphides occur as small inclusions in the silicate host. These sulphides were identified by electron microprobe analyses and include polydymite (Ni_3S_4), cobaltian pentlandite ($(Ni,Fe,Co)_9S_8$) and millerite (NiS). The nickel sulphides range in size from 3 to 110 microns. Cobalt was found only as a minor constituent of the pentlandite (about 10 wt %).

Nickel analysis by the microprobe showed that the magnetite contains 0.5 to 1.1 wt %, forsterite 0.2 wt % with no nickel detected in the chromite or the antigorite.

No. NG-77-S-26

In this sample, forsterite and antigorite are the principal minerals. They contain numerous small grains of magnetite and several large chromite grains. The major nickel phase in a (Ni,Fe) alloy close to the composition of awaruite. Since all the grains were less than 8 microns, it was difficult to obtain an accurate quantitative analysis, but semi-quantitatively the grains contain from 77.2 to 81.8 wt % Ni and from 12.3 to 15.2 wt % Fe.

Electron microprobe analyses showed that the magnetite contains 0.36 wt % Ni, forsterite 0.08 wt % Ni and antigorite 0.17 wt % Ni.

No. SH-77-S-302

This sample consists of massive serpentine cut by a few thin veinlets of dolomite. The serpentine contains numerous minute grains of magnetite and minor zoned chromite. Electron microprobe analyses of the magnetite gave 0.9 wt % Ni and that of the serpentine 0.11 wt % Ni. Nickel was not detected in the chromite.

No. BK-77-SR-160

The mineralogy of this ore sample differs radically from the first three samples. It consists essentially of large nodules of magnesite in a siliceous talc matrix. Minor amounts of calcite occur either as veinlets in the talc or as partial rims on some of the magnesite. No sulphides were observed in the sample. The principal ore mineral consists of numerous blade-like grains of hematite with a few lacy grains of chromite and several grains of magnetite. Thin discontinuous rims of iron hydroxide (goethite) surround but do not adjoin many of the magnesite nodules.

Electron microprobe analyses showed that the talc contains 0.25 wt % Ni, magnetite 0.32 wt % Ni, goethite 0.15 wt % Ni and chromite 0.10 wt % Ni.

No. KA-77-SR-175

This sample is composed mainly of magnesite with a few small clusters of chlorite. Minor sulphide mineralization consists of pyrite with several grains of polydymite, millerite, chalcopyrite and rutile. Most of the pyrite and all the chalcopyrite are enclosed by a rim of goethite in the magnesite matrix. The pyrite and chalcopyrite grains range up to 150 microns in size, whereas, the nickel sulphides are smaller than 25 microns.

Microprobe analyses of the pyrite showed it contains variable amounts of nickel (0.47 to 1.64 wt %) and cobalt (0.3 to 1.1 wt %). The nickel content of the goethite ranges from 0.4 to 1.3 wt % Ni and that of the chlorite from 0.45 to 0.90 wt % Ni.

CHEMICAL ANALYSES

The selection of chemical analyses made on the ten ore samples was based on the results of the mineralogical examination. Cobalt was not included in the analyses of any of the nickel-type ores due to its infrequent occurrence in low levels of concentration in some pyrite and in a few of the nickel sulphides. The results of the chemical analyses are summarized in Table 3.

TABLE 3

Chemical Analyses of the 10 Samples

Sample No.	Weight Percent		Oz/Ton	
	Ni*	Cu	Ag**	Au
NL-77-RSST-231	-	-		
NL-77-RSST-234	-	-		
SK-77-T-247	-	1.41		-
SK-77-R-249	-	0.29		-
SG-77-SSR-310	-	9.28		-
RK-77-S-20	0.24	-	-	-
NG-77-S-26	0.23	-	-	-
BK-77-SR-160	0.04	-	-	-
KA-77-SR-175	0.13	0.01	-	-
SH-77-S-302	0.21	-	-	-

* The nickel values are for soluble nickel only, i.e. nickel as a sulphide, alloy or oxide. This does not include the nickel as a trace element in the various silicates.

**The gold and silver analyses were not completed in time for this report. They will be forwarded under separate cover when completed.

ACKNOWLEDGEMENTS

The author wishes to express his appreciation to Mr. Y. Bourgoin for preparation of the polished sections; to Mr. J. Stewart for the X-ray powder diffraction studies and to Mr. J. Hole and Mr. D. Curley, Chemical Laboratory for the analyses.

/tab

POOR

QUALITY

ORIGINAL